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Docket No.: 17559/002001
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Letters Patent of:
Dominic McCann et al.

Patent No.: 7,699,561

Issued: April 20, 2010

For: METHOD AND SYSTEM FOR STORING LIQUID IN A GEOLOGICAL FORMATION

REQUEST FOR CERTIFICATE OF CORRECTION
PURSUANT TO 37 CFR 1.322

Attention: Certificate of Correction Branch
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

Upon reviewing the above-identified patent, Patentee noted a typographical error which should be corrected.

In the Claims:

In Claim 5, Column 13, Line 24, the word "modified" should read --**modified,**--.

The error was not in the application as filed by applicants; accordingly no fee is required.

751626

Transmitted herewith is a proposed Certificate of Correction effecting such amendment. Also enclosed are the claims as issued and the claims as amended. Patentee respectfully solicits the granting of the requested Certificate of Correction.

Applicants believe no fee is due with this request. However, if a fee is due, please charge our Deposit Account No. 50-0591, under Order No. 17559/002001.

Dated: June 18, 2010

Respectfully submitted,

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The recovery efficiency of the plurality of wells may be increased by using an appropriate storage model to select each well individually when injecting or extracting fresh water. The storage model describes the behaviour of the fresh water in the storage zones and allows to correlate these behaviours.

FIG. 11*a* and FIG. 11*b* contain a view from above over a field of wells **112** during an injection process. The wells **112** are disposed in such a way to have one central well **112***a* and a plurality of peripheral wells **112***b*. A position and a distribution of wells may be defined by the storage model of the concerned aquifer depending on available storage zones in the aquifer and other aquifer or geological characteristics.

As is represented in FIG. 11*a*, fresh water is injected at first through the central well **112***a*. After a determined delay, fresh water is also injected through the peripheral wells **112***b*, creating a zone of fresh water **114** as shown in FIG. 11*b*

The determined delay may be derived using an appropriate storage model.

As an example, a delay may be derived using measurements of the quality of the water. In this case, a sensor (not shown in FIG. 11*a*) is respectively provided for each well **112***a* and **112***b*. Each sensor measures the TDS content for the storage zone corresponding to the screen of the concerned well. When the TDS content measured at one of the sensors of the peripheral wells **112***b* has a value below the pre-defined threshold value, it may be considered, according to the storage model, that the zone of fresh water **114** created in the aquifer has increased in size and reached the corresponding peripheral well **112***b*. Fresh water may then be injected from any one of the corresponding peripheral wells **112***b*. The method according to the invention allows to avoid the traps of brackish water known from prior art.

Similarly, the appropriate storage model may be used for the extraction of liquid. In a first step, the screens of the peripheral wells **112***b* are opened, and the water is extracted through the peripheral wells **112***b*. When the TDS content measured at one of the sensors of the peripheral wells **112***b* reaches the pre-defined threshold value, it is considered, according to the storage model, that the zone of fresh water **114** has shrunk and is then mainly concentrated around the central well **112***a*. The screens of the peripheral wells **112***b* are then closed, and the liquid is now extracted only from the central well **112***a*.

Alternatively, the screens of the peripheral wells **112***b* may also be closed after a delay that is evaluated using the storage model, e.g., a delay that corresponds to a predetermined amount of water extracted from the peripheral wells.

In a first alternative embodiment, a plurality of wells is provided, each well comprising a plurality of screens. The flow of liquid through each screen is individually controllable. The storage model may take into consideration variations of the shape of the zone of fresh water with depth, and with width, thus providing a more complete storage model.

Each well has at least one sensor that measures the quality parameter of the liquid. The quality parameter may be a Total Dissolved Salt contents, or any other pollution parameter.

One possible extraction exploitation of the first alternative embodiment provides to authorize extraction from the aquifer only from the peripheral wells in a first step. The lowest open screens of each peripheral well are closed one after the other, as the measured quality parameter increases and reaches the pre-defined threshold value. After the delay, the central well is also authorized to extract liquid.

In a second alternative embodiment, during extraction, a plurality of sensors is provided respectively for each well. Each sensor corresponds to one of the screens. In a first step, only the peripheral wells are authorized to extract water from the aquifer; and, when the TDS content measured at one of the sensors of one the peripheral wells reaches the predetermined threshold value, the corresponding screen is closed. After the delay, the central well is also authorized to extract liquid and the screens that are disposed on its longitudinal axis are controlled according to the measurements of the TDS content of the corresponding storage zones.

In the second alternative embodiment, the flow of liquid through each well is controlled, and so is the flow through each screen of each well, thus resulting in a 3D operational control of the extraction process. The 3D operational control may of course also be performed for an injection process.

The examples described in this specification generally show wells in a substantially vertical position. It is understood that the well may well be in a different deviated direction rather than being vertical. A deviated well may be used in order to take into consideration a particular geological structure. This applies to all examples described in this specification.

It is understood that the TDS quality parameter is frequently used as an example in the present description but that any other quality parameter may be used instead or in combination. Also the quality parameter is often compared to a threshold in the present description but may alternatively be compare to a range of values.

While the invention has been described with respect to a limited number of embodiments, those skilled in the art, having benefit of this disclosure, will appreciate that other embodiments can be devised which do not depart from the scope of the invention as disclosed herein. Accordingly, the scope of the invention should be limited only by the attached claims.

The invention claimed is:

1. A method for improving the recovery efficiency of storing fresh water into an aquifer using a storage model of the aquifer, the storing comprising injecting the fresh water and extracting injected fresh water by a single water storage system comprising at least one well penetrating the aquifer, the method comprising:

controlling a plurality of screens, each of the plurality of screens being located alongside a wall of the at least one well, and each of the plurality of screens respectively allowing a flow of fresh water between an associated storage zone in contact with the screen and the at least one well on which the screen is located;

determining, in the storage model, a behavior of each associated storage zone using a plurality of geological characteristics of the aquifer;

receiving data from a plurality of sensors, wherein each of the plurality of sensors measures and monitors a quality parameter of water at one of the plurality of screens;

determining that the quality parameter of water has reached a predetermined threshold using at least one sensor of the plurality of sensors;

using the storage model to simulate an interaction between the injected fresh water and native water from each associated storage zone using the behavior of each associated storage zone, the data received from the plurality of sensors, and the quality parameter that has reached the predetermined threshold;

determining, based on the interaction, that the flow of fresh water from one or more screens of the plurality of screens should be modified to maintain or improve produced water quality of the at least one well; and

adjusting the one or more screens to maintain or improve the produced water quality of the at least one well.

2. The method according to claim 1, wherein the single water storage system comprises only one well penetrating the aquifer.

3. The method according to claim 2, further comprising:

extracting the fresh water from the aquifer;

monitoring the quality parameter of the extracted fresh water at an exit of the single well;

following determining that the flow of fresh water from the one or more screens should be modified, selecting an additional screen, wherein the additional screen is the deepest screen alongside the single well allowing the flow of fresh water among the plurality of screens;

closing the additional screen to stop the flow of fresh water through the additional screen.

4. The method according to claim 3, wherein the quality parameter is a total dissolved salt parameter.

5. The method according to claim 2, further comprising:

extracting the fresh water from the aquifer;

monitoring the quality parameter of the fresh water at each screen of the plurality of screens using the plurality of sensors;

following determining that the flow of fresh water from the one or more screens should be modified selecting an additional screen, wherein the additional screen corresponds to a location alongside the single well at which the quality parameter reaches the predetermined threshold;

adjusting the additional screen to modify the flow of fresh water through the additional screen.

6. The method according to claim 5, further comprising:

activating a closing mechanism at the additional screen to stop the flow of fresh water through the additional screen.

7. The method according to claim 6, wherein the quality parameter is a total dissolved salt parameter.

8. The method according to claim 5, wherein the quality parameter is a total dissolved salt parameter.

9. The method according to claim 2, further comprising:

injecting the fresh water into the aquifer through the one or more screens, the one or more screens being located as the deepest of the plurality of screens alongside the single well;

monitoring the quality parameter of liquid at an outside part of each screen of the plurality of screens distinct from the one or more screens, the outside part being in contact with a storage zone;

selecting an additional screen among the plurality of screens following identifying the screen, the additional screen being distinct from the one or more screens, and the additional screen corresponding to a location alongside the single well at which the quality parameter reaches the predetermined threshold;

adjusting the additional screen to modify the flow of fresh water through the additional screen.

10. The method according to claim 9, wherein the quality parameter is a total dissolved salt parameter.

11. The method according to claim 2, wherein the quality parameter is a total dissolved salt parameter.

12. The method according to claim 1, further comprising:

providing the at least one well;

providing at least one peripheral well, the at least one peripheral well being distinct from the at least one well;

providing at least one screen from the plurality of screens for respectively each one of the at least one well and the at least one peripheral well.

13. The method according to claim 12, further comprising:

injecting the fresh water into the aquifer through a screen located alongside the at least one well;

monitoring the quality parameter of liquid at an outside part of each screen located on the at least one peripheral well, the outside part of each screen being in contact with a storage zone;

following determining that the flow of fresh water from the one or more screens should be modified, selecting an additional screen at which the quality parameter reaches the predetermined threshold;

injecting the fresh water into the aquifer through the at least one peripheral well on which the additional screen is located.

14. The method according to claim 13, wherein the quality parameter is a total dissolved salt parameter.

15. The method according to claim 12, wherein the quality parameter is a total dissolved salt parameter.

16. The method according to claim 1, wherein the quality parameter is a total dissolved salt parameter.

17. The method according to claim 1, further comprising:

injecting the fresh water into the aquifer;

extracting the fresh water from the aquifer;

the determining that the flow of fresh water from the one or more screens of the plurality of screens should be modified and the adjusting being performed such as to keep the quality parameter of the fresh water being extracted in a desired range;

interrupting the extracting of the fresh water when the quality parameter is outside of the desired range.

18. The method according to claim 17, wherein the injecting, the extracting and the interrupting are repeated in at least one cycle following the interrupting.

19. The method according to claim 18, wherein the interrupting comprises selectively interrupting the extracting from one determined storage zone of the aquifer when the quality parameter from the fresh water extracted out of the determined storage zone is outside the desired range.

20. The method according to claim 17, wherein the interrupting comprises selectively interrupting the extracting from one determined storage zone of the aquifer when the quality parameter from the fresh water extracted out of the determined storage zone is outside the desired range.

21. The method of claim 1 wherein adjusting the one or more screens is affected by changing a position of a seal inside the well in the proximity of the one or more screens.

22. The method of claim 1 wherein adjusting the one or more screens is affected by changing a position of a plug inside the well in the proximity of the one or more screens.

23. The method of claim 1 wherein adjusting the one or more screens is affected by changing a flow connection inside the well in the proximity of the one or more screens.

* * * * *

AMENDMENTS TO THE CLAIMS

Please amend the claims as follows.

1. (Currently Amended) A method for improving the recovery efficiency of storing fresh water into an aquifer using a storage model of the aquifer, the storing comprising injecting the fresh water and extracting [[the]] injected fresh water by a single water storage system comprising at least one well penetrating the aquifer, the method comprising:

controlling ~~providing~~ a plurality of screens, each of the plurality of screens ~~screen~~ being located alongside a wall of the at least one well, and each of the plurality of screens ~~screen~~ respectively allowing a flow of fresh water between an associated storage zone in contact with the screen and the at least one well on which the screen is located; [[and]]

determining, in the storage model, a behavior of each associated storage zone using a plurality of geological characteristics of the aquifer;

receiving data from a plurality of sensors, wherein each of the plurality of sensors measures and monitors a quality parameter of water at one of the plurality of screens;

determining that the quality parameter of water has reached a predetermined threshold using at least one sensor of the plurality of sensors;

using the storage model to simulate an interaction between the injected fresh water and native water from each associated storage zone using the behavior of each associated storage zone, the data received from the plurality of sensors, and the quality parameter that has reached the predetermined threshold;

~~controlling the flow of fresh water through each one of the plurality of screens according to parameters provided from a storage model of the aquifer, the storage model describing a behavior of each storage zone~~

determining, based on the interaction, that the flow of fresh water from one or more screens of the plurality of screens should be modified to maintain or improve produced water quality of the at least one well; and

adjusting the one or more screens to maintain or improve the produced water quality of the at least one well.

2. (Cancelled)

3. (Currently Amended) The method according to claim 1 [[2]], ~~further comprising: providing the plurality of screens, each screen being located alongside the wall of a single well~~ wherein the single water storage system comprises only one well penetrating the aquifer.

4. (Currently Amended) The method according to claim 3, further comprising:

extracting the fresh water from the aquifer;

monitoring the quality parameter of the extracted fresh water at an exit of the single well;

following determining that the flow of fresh water from the one or more screens should be modified, selecting an [[open]] additional screen ~~following the triggering~~, wherein the [[open]] additional screen ~~being located as~~ is the deepest [[open]] screen alongside the single well allowing the flow of fresh water among ~~all open screens of~~ the plurality of screens;

closing the additional screen to stop ~~stopping~~ the flow of fresh water through the ~~selected open~~ additional screen.

5. (Cancelled)

6. (Currently Amended) The method according to claim 3, further comprising:

extracting the fresh water from the aquifer;

monitoring the quality parameter of the fresh water at each screen of the plurality of screens using the plurality of sensors;

following determining that the flow of fresh water from the one or more screens should be modified, selecting an [[open]] additional screen ~~following the triggering~~, wherein the [[selected]] additional screen ~~corresponding~~ corresponds to a location alongside the single well at which the quality parameter reaches the ~~critical~~ predetermined threshold ~~value~~;

~~stopping~~ adjusting the additional screen to modify the flow of fresh water through the ~~selected open~~ additional screen.

7. (Currently Amended) The method according to claim 6, further comprising:

activating a closing mechanism at the ~~selected~~ additional screen [[,]] to stop the flow of fresh water through the ~~selected~~ additional screen.

8. (Currently Amended) The method according to claim 3, further comprising:

injecting the fresh water into the aquifer through ~~a first screen~~ the one or more screens, the one or more screens ~~first screen~~ being located as the deepest of the plurality of screens ~~screen~~ alongside the single well;

monitoring the quality parameter of liquid at an outside part of each screen of the plurality of screens distinct from the one or more screens ~~first screen~~, the outside part being in contact with a storage zone;

selecting ~~a second~~ an additional screen among the plurality of screens following identifying the ~~triggering~~ screen, the ~~second~~ additional screen being distinct from the one or more screens ~~first screen~~, and the ~~second~~ additional screen corresponding to a location alongside the single well at which the quality parameter reaches the predetermined threshold ~~critical value~~;

~~enabling~~ adjusting the additional screen to modify the flow of fresh water through the ~~second~~ additional screen.

9. (Currently Amended) The method according to claim 1 [[2]], further comprising:

providing the at least one ~~a main~~ well;

providing at least one peripheral well, the at least one peripheral well being distinct from the at least one ~~main~~ well;

providing at least one screen from the plurality of screens for respectively each one of the ~~main~~ at least one well and the at least one peripheral well ~~wells~~.

10. (Currently Amended) The method according to claim 9, further comprising:

injecting the fresh water into the aquifer through a screen located alongside the at least one ~~main~~ well;

monitoring the quality parameter of liquid at an outside part of each screen located on [[a]] the at least one peripheral well, the outside part of each screen being in contact with a storage zone;

following determining that the flow of fresh water from the one or more screens should be modified ~~the triggering~~, selecting [[a]] an additional screen at which the quality parameter reaches the predetermined threshold ~~critical value~~;

injecting the fresh water into the aquifer through the at least one peripheral well on which the ~~selected~~ additional screen is located.

11. (Currently Amended) The method according to claim [[2]] 1, wherein [[:]] the quality parameter is a total dissolved salt parameter.

12. - 22. (Cancelled)

23. (Currently Amended) The method according to claim 1 [[2]], further comprising:

injecting the fresh water into the aquifer;

extracting the fresh water from the aquifer;

the ~~selecting~~ determining that the flow of fresh water from the one or more screens of the plurality of screens should be modified and the ~~modifying~~ adjusting being performed such as to keep the quality parameter of the fresh water being extracted in a desired range;

interrupting the extracting of the fresh water [[if]] when the quality parameter is outside of the desired range.

24. (Original) The method according to claim 23, wherein the injecting, the extracting and the interrupting are repeated in at least one cycle following the interrupting.

25. (Currently Amended) The method according to claim 23, wherein the interrupting comprises selectively interrupting the extracting from one determined storage zone of the aquifer [[if]]

when the quality parameter from the fresh water extracted out of the determined storage zone is outside the desired range.

26. (Currently Amended) The method according to claim 3, wherein [[:]] the quality parameter is a total dissolved salt parameter.

27. (Currently Amended) The method according to claim 4, wherein [[:]] the quality parameter is a total dissolved salt parameter.

28. (Cancelled)

29. (Currently Amended) The method according to claim 6, wherein [[:]] the quality parameter is a total dissolved salt parameter.

30. (Currently Amended) The method according to claim 7, wherein [[:]] the quality parameter is a total dissolved salt parameter.

31. (Currently Amended) The method according to claim 8, wherein [[:]] the quality parameter is a total dissolved salt parameter.

32. (Currently Amended) The method according to claim 9, wherein [[:]] the quality parameter is a total dissolved salt parameter.

33. (Currently Amended) The method according to claim 10, wherein [[:]] the quality parameter is a total dissolved salt parameter.

34. (Cancelled)

35. (Cancelled)

36. (Currently Amended) The method according to claim 24, wherein the interrupting comprises selectively interrupting the extracting from one determined storage zone of the aquifer [[if]] when the quality parameter from the fresh water extracted out of the determined storage zone is outside the desired range.

37. (New) The method of claim 1 wherein adjusting the one or more screens is affected by changing a position of a seal inside the well in the proximity of the one or more screens.

38. (New) The method of claim 1 wherein adjusting the one or more screens is affected by changing a position of a plug inside the well in the proximity of the one or more screens.

39. (New) The method of claim 1 wherein adjusting the one or more screens is affected by changing a flow connection inside the well in the proximity of the one or more screens.

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UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO.	:	7,699,561
APPLICATION NO.	:	10/561,640
ISSUE DATE	:	April 20, 2010
INVENTOR(S)	:	Dominic McCann et al.

It is certified that an error appears or errors appear in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In Claim 5, Column 13, Line 24, the word "modified" should read --**modified,**--.

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751628

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